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AUTHOR Melancon, Janet G.; Thompson, Bruce
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ABSTRACT

This study applied one-parameter latent trait measurement theory to investigate the measurement characteristics of both forms of a multiple-choice measure of field-independence--the Finding Embedded Figures Test (FEFT). The FEFT has a multiple-choice format that may facilitate administration and scoring in comparison with use of supply-format tests such as the Group Embedded Figures Test (GEFT). Analysis was based on data provided by 302 students enrolled in mathematics courses at a university in the southern United States. Subjects were randomly assigned to one of four conditions: (1) GEFT and Form A FEFT (n=70); (2) GEFT and Form B FEFT (n=77); (3) Form A FEFT completion followed by Form B (n=76); and (4) Form B FEFT completion followed by Form A (n=79). Results suggest that the FEFT forms provide data with reasonable psychometric integrity. In addition to presenting results associated with the FEFT forms, the paper also provides a model for presenting and interpreting Rasch latent trait results. A 52-item reference list is provided. Seven data tables and 15 figures conclude the document. (TJH)

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LATENT TRAIT MEASUREMENT CALIBRATIONS FOR THE FINDING EMBEDDED FIGURES TEST

Janet G. Melancon
Loyola University of the South

Bruce Thompson
University of New Orleans
and
L S U Medical Center

Paper presented at the annual meeting of the Mid-South Educational Research Association, Louisville, KY, November 10, 1988.

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ABSTRACT

The study applied latent trait measurement theory to investigate the measurement characteristics of both forms of a multiple choice measure of field-independence, the Finding Embedded Figures Test. Analysis was based on data provided by 302 subjects. Results suggest that the FEFT forms provide data with reasonable psychometric integrity. In addition to presenting results associated with the FEFT forms, the paper also provides a model for presenting and interpreting Rasch latent trait results.

In the years immediately following World War II, Herman A. Witkin and his colleagues performed a series of historically important studies (e.g., Witkin, 1949) involving stylistic variations in perceptions of visual stimuli. These initial studies investigated variations in ability to perceive the upright in the absence of normally-available orienting stimuli. Witkin, Moore, Goodenough and Cox (1977, pp. 3-4) present photographs of the apparatuses used in these early "rod-and-frame" and "body-adjustment" tests. Heesacker (1981) presents a summary of the early years of this important research, and of the antecedents of the work dating back to the previous century (Jastrow, 1892).

Witkin's early work led to the development of the theory of psychological differentiation and the delineation of a cognitive style that has come to be called field independence/dependence (Goodenough & Witkin, 1977, pp. 2-3). As Witkin (1979, p. 359) explains,

> We designate the tendency to rely on the self as a primary referent in information processing as a field-independent mode of functioning and the tendency to rely on external referents as a field-dependent mode of functioning. These tendencies find widespread expression in an individual's perceptual, intellectual, and social activities.

Persons who tend to operate on the field independence (FI) end of this cognitive style continuum tend to perceive themselves as more segregated from their environments; these persons tend to be more analytical in their abilities and interests.

Persons who tend to operate on the field dependence (FD) end of the continuum, on the other hand, tend to be less able either to distinguish among or to reorganize stimuli. More field dependent persons also tend to be more social in their abilities and interests. Thus, more field-dependent persons have a greater preference to be with people (Bard, 1972; Coates, Lord & Jakobovics, 1975) and may be more popular with their peers (Wong, 1976). Similarly, more field-dependent persons may be more attentive to social cues (Eagle, Goldberger & Breitman, 1969; Fitzgibbons & Goldberger, 1971; Ruble & Nakamura, 1972) and may even prefer to be physically closer to other people (Holley, 1972; Justice, 1969). In summary, as Jacobs and Gedeon (1982, p. 19) explain,

> Field independent persons are those who tend to process information with greater isolation from their environment. Thus, they have been shown to have less sensitivity to social cues and less developed interpersonal skills; they tend to process information more analytically since parts of their environment are more apparent to them.

Field independence is the most researched of the 19 cognitive styles that have been identified (Goldstein & Blackman, 1978; Messick, 1976). For example, a comprehensive bibliography of studies involving the field-independence construct cites several thousand studies (Cox & Gall, 1981). Various researchers (cf. Donlon, 1977, p. 1; Witkin, Moore, Goodenough & Cox, 1977, p. 1) concur that the construct of field-independence has

stimulated great interest:

> Of the several cognitive style dimensions thus far identified in the research literature, field dependence-independence has received the most attention. (Laosa, 1978, p. 3)

> Cognitive style research is being applied at an ever increasing rate to the problems of education. The field-dependence/field-independence dimension described by Witkin and his associates has been one of the most widely studied styles. (Doebler & Eicke, 1979, p. 226)

> Field dependence/independence has been studied extensively for over three decades (Witkin, Moore, Goodenough, and Cox, 1977). Of all the cognitive styles it is by far the most well-researched and has the greatest application potential to educational problems... This is clearly no overnight product of some academic fad. (Rasinski, 1983, p. 1)

Numerous studies indicate that field-independence has noteworthy associations with myriad outcomes; several reviews of these studies are available elsewhere (cf. Goodenough, 1976; Goodenough & Witkin, 1977; Melancon & Thompson, 1987; Witkin, Moore, Goodenough & Cox, 1977). However, the general tenor of these diverse findings can be gleaned by considering a few of the many available citations. Field-independence has been found to be related to marital satisfaction (Sabatelli, 1982); to vocational

choice (Witkin, Moore, Oltman, Goodenough, Friedman, Owen & Raskin, 1977); to general academic achievement during elementary school years (Wicker, 1980) and in certain cases in older subject groups (Donnarumma, Cox & Beder, 1980); to problem-solving abilities (Ronning, McCurdy & Ballinger, 1984); to concept-learning abilities (Stasz, Shavelson, Cox & Moore, 1976); and to performance in specific subject areas such as art (Copeland, 1983), engineering graphics (Wilson & Davis, 1985), and reading (Pitts & Thompson, 1984; Spiro & Tirre, 1979). Field-independence also affects reaction to different instructional interventions and conditions (cf. Bolocofsky, 1980; Frank & Davis, 1982; Jolly & Strawitz, 1984; Paradise & Block, 1984; Renninger & Snyder, 1983; Saracho, 1980).

Witkin and his colleagues eventually discovered that the ability to perceive the upright was associated with the ability to disembed or locate figures hidden in a stimulus field. Thus, perceptual disembedding tasks have frequently been used in research "in place of the rather complex gadgets required for some of the early laboratory tests of field-dependence-independence" (Witkin, Moore, Goodenough & Cox, 1977, p. 7). Cox and Gall (1981, p. 5) cite 16 measures that have been employed with varying frequency to measure aspects of perceptual disembedding ability. Campbell and Donlon (1980) report initial development of a disembedding measure that was administered to 12,681 adults as part of a GRE administration.

However, the most frequently used measures have been the Preschool Embedded Figures Test (PEFT) (Coates, 1972), the

Children's Embedded Figures Test (CEFT) (Witkin, Oltman, Raskin & Karp, 1971), and the Group Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971). The Group Embedded Figures Test (GEFT) has been frequently used, in part because the measure has exceptional psychometric integrity even when evaluated by sophisticated measurement theory such as generalizability theory (Thompson & Melancon, 1987b), or when used with children (Thompson, Pitts & Gipe, 1983).

Although the GEFT has proven to be a very useful measure of aspects of field independence, the measure does have some limitations. The primary limitation is that the GEFT employs a "supply" format in which subjects actually draw on the target figure embedded within a stimulus. As Donlon (1977, pp. 1-2) notes, "From the standpoint of a large-scale administration, however, the GEFT has the drawback of requiring trained personnel to score each item."

Melancon and Thompson (1987) present in detail the first phase of development of a multiple-choice perceptual disembedding measure, the Finding Embedded Figures Test (FEFT). The FEFT (Thompson & Melancon, 1987a) was developed to provide a multiple-choice, machine-scoreable measure of perceptual disembedding or restructuring as an alternative to supply-format tests such as the GEFT. A multiple-choice test avoids difficulties associated with supply-format requirements for use of scorers and concerns about interrater reliability. The FEFT was also developed in the expectation that the use of another measure might shed additional light on the nature of the field-independence construct (Linn & Kyllonen, 1980, p. 1).

A five-choice item response format was selected for use on the Finding Embedded Figures Test (FEFT) in order to maximize "true" test length and reliability (Thompson & Levitov, 1985, pp. 164-165). An initial item pool of 110 items was developed (Melancon & Thompson, 1987). Each item presents a target figure which is located in only one of the five response alternatives. As used in the present study, subjects respond to each item by indicating the letter code for the response alternative containing the target.

Melancon and Thompson (1987) calculated item-to-total FEFT score correlation coefficients, i.e., coefficients between item scores ("0" or "1") and total FEFT test scores; these coefficients were reported as "internal validity" coefficients. The researchers also reported "external validity" correlation coefficients, i.e., coefficients between total FEFT item scores and total GEFT scores, as well as "total validity" coefficients, i.e., coefficients between FEFT item scores and scores on the combination of the FEFT and the GEFT measures. Since the last coefficients involved the most information, they were considered to be especially important in making decisions about eventual item retention.

Based on the results in the initial study of a pool of 110 items, two forms ("A" and "B") of the FEFT were developed. Both Form "A" and Form "B" of the FEFT consist of the 35 items. The forms each share 15 "linking" or common items. The linking items can be employed to equate scores across forms, or to estimate test-retest reliability if both forms are administered to

subjects.

The considered development efforts reported previously (Melancon & Thompson, 1987) may have optimized the measurement integrity of the FEFT. The present study was conducted to evaluate the measurement integrity of the two final forms of the FEFT. Specifically, the present study was conducted to evaluate the measurement characteristics of the FEFT using one-parameter latent trait measurement theory (McKinley, in press; Wright & Stone, 1979). Latent trait measurement theory is a powerful approach to evaluating measurement integrity (Traub & Wolfe, 1981), as explained by Thompson and Barnitz (1981) and illustrated by Pitts and Thompson (1984).

Method

Subjects

Subjects (n=302) were all the students enrolled in mathematics courses at a university in the southern United States. Slightly more students (52.7%) were male rather than female. The mean age of the students was 19.52 (SD=3.06).

Subjects were randomly assigned in class units to one of four conditions: (a) GEFT and Form A FEFT (n=70); (b) GEFT and Form B FEFT (n=77); (c) Form A FEFT completion followed by Form B (n=76); (d) Form B FEFT completion followed by Form A (n=79). Eta-squared was computed to determine the proportion of variance in FEFT Form A scores associated with assignment to the three groups ("a", "c" or "d") that received the measure; the calculated value (.032) suggests that the groups did not differ appreciably. The comparable eta-squared statistic (.035) for

persons with Form B scores similarly suggests that persons in the groups ("b", "c" or "d") did not differ appreciably.

Results

As noted in explanations of latent trait measurement theory (e.g., Thompson & Barnitz, 1981), one important feature of this measurement approach is that the measurement model presumes that subjects should get items correct based on their latent abilities. Thus, a subject with the ability to correctly answer 35 items should get the 35 easiest items right, and the remaining items should be incorrectly answered.

It is quite noteworthy that the one-parameter latent trait measurement theory can be employed to identify which subjects, if any, substantially deviate from performance expectations. Such subjects can be removed from further analysis. The ability to identify such subjects is important to efforts to interpret results provided only by subjects who were consistent in their behavior and who systematically made their best attempts to correctly answer test items. Of course, when few subjects deviate from these performance expectations, such results also allow the researcher to vest more confidence in interpretations grounded in a given set of data.

An initial step in the analysis requires that all subjects with zero correct answers or with perfect scores be deleted from the analysis. Such subjects have no item response variance that can be considered in the analysis. On this basis, three of the 225 subjects who completed Form A were removed from the analysis, and two of the 232 subjects who completed Form B were removed.

Table 1 identifies the eight subjects whose responses on FEFT Form A substantially deviated from performance expectations. These eight subjects had "fit" t statistics that were highly improbable. In the present analysis, a t statistic greater than 2.00 was deemed sufficiently improbable to consider a response pattern aberrant. Similarly, Table 2 identifies the four subjects whose responses substantially deviated from latent trait model expectations.

INSERT TABLES 1 AND 2 ABOUT HERE.

Figure 1 presents a scattergram plotting fit statistics for the 222 persons who provided the basis for the analysis of Form A data with these subjects' initial latent trait ability estimates. The eight subjects with aberrant response patterns are identified in the top portion of the plot above the horizontal line across the graph. Figure 2 presents comparable results for the 220 subjects who provided the basis for analysis of Form B.

INSERT FIGURES 1 AND 2 ABOUT HERE.

A second noteworthy feature of latent trait measurement is that, if the model fits the data, estimates of latent person ability will be independent of the sample of items, i.e., will generalize across item samples. Figure 3 presents the "item characteristic curve" that ties raw scores to latent "log ability" estimates for the FEFT Form A data. Figure 4 presents comparable results for the FEFT Form B data.

INSERT FIGURES 3 AND 4 ABOUT HERE.

A third noteworthy feature of latent trait measurement is that, if the model fits the data, estimates of item difficulty calibrations will be independent of the sample of persons, i.e., will generalize across samples of people. One way to evaluate whether the latent trait model fits the data, i.e., that item difficulty calibrations generalize across person samples, is to divide the sample into subgroups and then conduct separate item calibrations. These results are presented for both FEFT Form A and FEFT Form B items in Tables 3 and 4, respectively.

INSERT TABLES 3 AND 4 ABOUT HERE.

A fourth noteworthy feature of latent trait measurement is that the model can be used to detect items that deviate too substantially from performance expectations, i.e., are answered correctly by too many persons with lower ability or are missed by too many persons with higher ability. Furthermore, if few or no items deviate from model expectations, more confidence can be vested in conclusions about measurement integrity based on results.

Tables 5 and 6 present the FEFT Form A and Form B items listed in order of the item "fit" t statistics. Items with t statistics greater than 2.00 in absolute value can be considered as having deviated rather substantially from model expectations. The two forms of the FEFT each include 15 common or linking items. Table 7 summarizes the item statistics for these items, as the statistics for the items were presented in Tables 5 and 6.

INSERT TABLES 5 THROUGH 7 ABOUT HERE.

Only eight subjects for Form A and four subjects for Form B substantially deviated from latent trait measurement model expectations, as reported in Tables 1 and 2. Only three items ("A030", "B004", and "B025") substantially deviated from model expectations, as reported in Tables 5 and 6. Because the preponderance of both subjects and items involved behavior closely corresponding with the expectations of the latent trait measurement model, the model can be employed to present meaningful "maps" of both people and items on the latent ability variables for FEFT Forms A and B. These maps are presented in Figures 5 and 6, respectively.

INSERT FIGURES 5 AND 6 ABOUT HERE.

Additional analyses can be conducted to identify whether item fit systematically differs across item difficulty. Figures 7 through 10 present plots of item fit statistics with latent trait item difficulty calibrations. Figures 11 and 12 provide the basis for determining whether item fit differs systematically across item discrimination. Figures 13 and 14 can be used to isolate items that "misfit" across two evaluations of item behavior, i.e., "total" and "between" statistics.

INSERT FIGURES 7 THROUGH 14 ABOUT HERE.

From among the 302 subjects, 153 subjects completed both forms of the FEFT. Since latent trait person ability estimates should be independent of item samples, the ability estimates calculated separately for all subjects who completed the forms

were correlated for the 155 subjects who completed both forms. Figure 15 presents a scattergram of these results. The bivariate correlation between the two sets of ability estimates was +0.75.

INSERT FIGURE 15 ABOUT HERE.

Discussion

The analysis of the Finding Embedded Figures Test's item characteristics using the one-parameter latent trait measurement theory indicated that the FEFT items generally performed in accord with expectations. As reported in Tables 1 and 2 and Figures 1 and 2, only eight of 222 (3.6%) and four of 230 (1.7%) subjects' performances on FEFT items substantially deviated from model expectations. As reported in Tables 5 and 6, only three items ("A030", "B004", "B025") substantially deviated from model expectations. Figures 13 and 14 confirm that these items tended to perform poorly across both types of item fit statistics.

Figures 7 through 12 indicate that item fit was not a systematic function of item difficulty or discrimination. Thus, the items are reasonable markers for latent ability throughout the range of the variable. Figure 15 suggests that latent trait ability estimates were generally comparable for the 153 subjects who completed both forms of the Finding Embedded Figures Test.

The cognitive style of field independence has attracted serious interest among researchers. As Heesacker (1981, p. 2) notes,

> Since the early 1960s literally hundreds of

research papers have looked at various aspects of field dependence. Field dependence is currently one of the most popular research topics in psychology.

The present study was conducted to investigate the measurement integrity of the Finding Embedded Figures Test (FEFT), a measure developed based on studies reported by Melancon and Thompson (1987). The FEFT has a multiple-choice format that may facilitate administration and scoring in comparison with the use of supply-format tests such as the GEFT. The results of the present study indicate that the FEFT forms have acceptable psychomteric integrity.

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Table 1

LIST OF PERSONS WITH FIT ABOVE 2.00: Form A (n=225-3=222)

SEQ NUM	PERSON NAME	TOTAL FIT t	PERSON ABILITY	ERROR	RESPONSES AND STANDARDIZED RESIDUALS
1	180	2.48	0.04	0.37	
	1 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 0 1 1 0 1 0 1 0 1 0 0 1 1 1 1 0 0 0				
	1 1-2 0 0 0 0 0 0 1 0 1 0 0 0 0 0-1 0 1-1 0-1 0-1 1-1-1 0 1 0 0-1-1-1				
2	720	2.13	-0.61	0.37	
	1 1 1 0 0 1 0 1 0 1 1 1 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0				
	1 1 0 0 0 1 0 1 0 1 1 1 1 0 0 1 0-1 0 0-1-1-1 0 0 0-1 1 0 0 0 0 1-1-1				
3	730	2.84	-0.21	0.37	
	1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1				
	1 1 0 0 2 1 2 1 0 1 0 1 1 0 0-1 0-1-1 0 0-2-1 0-1 0-1 1 0 0-1 0 0-1 0				
4	790	2.59	-0.61	0.37	
	1 1 0 0 0 0 0 1 1 1 1 1 0 0 1 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1				
	1 1-1 0 0 0 0 1 3 1 1 1 0 0 3 0 0 0 0 0-1 0-1 0 0 0-1 0 0 2 0 0 0-1 0				
5	2012	2.60	0.44	0.37	
	1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 0 1 0 1 1 1 0 0 1 0 0 1 1 0 1 1 0 0 0 0 0				
	1 0 0 0 1 0 1 0 0 1-1 0 0 0 0 0-1 0 0 1-1-2 0-1-1 0 0-1 0 1-1-1-1-1-1				
6	2062	2.85	0.44	0.37	
	1 1 1 0 0 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 0 1 1 0 0 1 1 0 1 0 0 0 0 0 0				
	1 0 0-1 0 0 1 0 2 0 0 0 0 0 1 0 0-2 0 1-1 0 0-1-1 0 0-1 0 0-1-1-1-1-1				
7	2453	2.24	-0.48	0.37	
	0 0 0 1 0 0 1 0 1 0 0 0 0 1 0 0 1 0 1 0 1 0 0 1 1 0 1 0 0 1 0 1 1 0 1				
	0 0-1 1 0 0 3 0 3 0 0 0 0 1 0 0 1-1 0 0 0-1-1 1 1 0 0 0 0 2 0 1 1-1 0				
8	2683	2.67	0.58	0.38	
	1 1 1 1 1 1 0 1 0 1 0 1 1 1 1 0 1 0 0 1 1 0 0 0 0 0 1 0 1 1 1 1 1 1 0				
	0 0 0 0 1 0 0 0 0 0-1 0 0 0 1-1 0-2-1 0 0-3-2-1-1-1 0-1 0 1 0 0 0 0-2				

Table 2

LIST OF PERSONS WITH FIT ABOVE 2.00: Form B (n=232-2=230)

SEQ NUM	PERSON NAME	TOTAL FIT t	PERSON ABILITY	ERROR	RESPONSES AND STANDARDIZED RESIDUALS
1	961	2.12	1.09	0.42	
	1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 0 1 0 0 1 1 1 0 0				
	0 1 2 0 0 0 0 0 0 0-1 0 0 1 0 0-1 1 0 0 0 0 0 0 0 0-1-2-3 0-2-1 0 0 0-4-1				
2	1341	2.13	-0.65	0.39	
	0 1 0 0 0 1 0 0 0 1 0 1 0 0 1 1 0 0 1 0 1 0 1 1 0 0 1 0 0 1 0 0 0 1 0				
	-1 3 0 0 0 3 0 0-1 1 0 1 0 0 0 1 0-1 0 0 0 0 1 1 0-1 0-1 0 2 0 0 0 0 0				
3	1431	2.77	0.33	0.38	
	0 1 1 1 1 0 1 1 0 0 0 1 0 0 0 1 1 1 1 1 1 1 0 0 1 1 0 1 1 0 0 0 1 1 1 0				
	-2 1 3 1 0 0 1 0-1 0-1 0 0-1-1 1 1 0 0 0 0-1-1 1 0-1 0 0-1 0-1 0 0 0 0				
4	2933	2.50	0.77	0.40	
	0 1 0 1 1 1 1 1 1 0 1 1 1 0 0 0 0 0 1 1 0 1 1 1 1 0 1 1 1 1 1 1 0 1 0				
	-3 1 0 0 0 1 1 0 0-1 0 0 2-1-2-1 0-2 0 0-2 0 0 0 0-2 0 0 0 1 0 0-1 0-1				

Note. The row of 35 item responses ("1"=right; "0"=wrong) is followed by a row of standardized item residuals indicating which item responses most deviated for an individual's expected item performance.

Table 3
ITEM CHARACTERISTIC CURVE: Form A
(n=225-3-8=214)

SEQ NUM	ITEM NAME	1ST GROUP	2ND GROUP	3RD GROUP	4TH GROUP	5TH GROUP	6TH GROUP
1	A001	0.31	0.39	0.58	0.75	0.81	0.87
2	A002	0.44	0.53	0.52	0.66	0.85	0.96
3	A003*	0.72	0.89	0.91	1.00	0.96	1.00
4	A004	0.41	0.69	0.76	0.91	0.81	0.96
5	A005	0.25	0.22	0.39	0.44	0.42	0.65
6	A006*	0.47	0.67	0.70	0.81	0.77	0.93
7	A007*	0.13	0.28	0.24	0.38	0.38	0.65
8	A008*	0.41	0.64	0.70	0.81	0.96	0.91
9	A009	0.19	0.36	0.24	0.22	0.35	0.62
10	A010*	0.38	0.36	0.70	0.69	0.73	0.89
11	A011	0.34	0.67	0.67	0.75	0.92	0.93
12	A012*	0.25	0.53	0.64	0.72	0.88	0.91
13	A013	0.34	0.42	0.58	0.72	0.92	0.93
14	A014*	0.69	0.83	0.76	0.84	0.85	0.85
15	A015*	0.13	0.22	0.33	0.41	0.42	0.60
16	A016*	0.47	0.69	0.88	0.97	0.88	0.91
17	A017	0.50	0.53	0.58	0.69	0.81	0.84
18	A018	0.56	0.89	0.94	1.00	1.00	1.00
19	A019*	0.50	0.81	0.79	0.88	0.96	1.00
20	A020*	0.22	0.50	0.61	0.75	0.69	0.89
21	A021*	0.72	0.81	0.85	0.84	1.00	0.98
22	A022*	0.88	0.94	0.97	0.91	1.00	0.98
23	A023	0.69	0.78	0.91	0.97	0.96	0.98
24	A024*	0.53	0.75	0.64	0.81	0.77	0.91
25	A025	0.44	0.86	0.94	0.78	0.85	0.96
26	A026	0.22	0.50	0.64	0.84	0.77	0.91
27	A027	0.69	0.81	0.91	0.91	0.88	0.98
28	A028	0.50	0.75	0.67	0.88	0.92	0.89
29	A029*	0.44	0.58	0.82	0.75	0.92	0.96
30	A030	0.22	0.58	0.42	0.41	0.58	0.64
31	A031	0.59	0.64	0.76	0.84	0.88	0.95
32	A032	0.59	0.69	0.85	0.72	0.92	0.95
33	A033	0.50	0.72	0.79	0.72	0.77	0.87
34	A034	0.72	0.75	0.91	0.84	0.92	0.96
35	A035	0.72	0.89	0.88	1.00	0.88	0.89
SCORE RANGE		1-20	21-23	24-25	26-27	28-29	30-34
MEAN ABILITY		-0.20	0.62	0.95	1.32	1.67	2.41
MEAN Z-TEST		0.0	0.1	0.1	0.1	0.1	0.2
SD(Z-TEST)		1.0	1.1	0.8	1.0	0.9	1.1
GROUP COUNT		32	36	33	32	26	55

Note. Asterisks designate the 15 linking items.

Table 4
ITEM CHARACTERISTIC CURVE: Form B
'n=232-2-4=226)

SEQ NUM	ITEM NAME	1ST GROUP	2ND GROUP	3RD GROUP	4TH GROUP	5TH GROUP	6TH GROUP
1	B001*	0.78	0.82	0.93	1.00	1.00	1.00
2	B002	0.11	0.30	0.35	0.37	0.39	0.64
3	B003	0.06	0.03	0.17	0.13	0.17	0.64
4	B004	0.44	0.57	0.57	0.58	0.64	0.78
5	B005*	0.42	0.73	0.80	0.82	0.89	0.89
6	B006*	0.14	0.17	0.30	0.39	0.50	0.64
7	B007	0.06	0.43	0.52	0.55	0.64	0.83
8	B008	0.44	0.55	0.70	0.58	0.92	0.92
9	B009*	0.61	0.82	0.73	0.84	0.94	0.94
10	B010	0.22	0.43	0.47	0.82	0.78	0.92
11	B011*	0.42	0.45	0.60	0.71	0.86	0.97
12	B012	0.50	0.50	0.65	0.71	0.81	0.97
13	B013	0.17	0.13	0.15	0.24	0.28	0.72
14	B014*	0.36	0.60	0.65	0.74	0.75	0.92
15	B015*	0.78	0.77	0.82	0.89	0.94	0.94
16	B016	0.39	0.40	0.57	0.71	0.78	0.94
17	B017*	0.14	0.25	0.35	0.32	0.50	0.69
18	B018*	0.47	0.85	0.93	0.92	0.97	0.97
19	B019	0.78	0.95	0.98	1.00	1.00	1.00
20	B020	0.42	0.63	0.77	0.79	1.00	1.00
21	B021*	0.75	0.82	0.90	0.92	0.92	0.97
22	B022*	0.28	0.57	0.75	0.87	0.94	0.94
23	B023	0.47	0.68	0.70	0.68	0.72	0.89
24	B024	0.17	0.38	0.50	0.71	0.67	0.89
25	B025	0.25	0.40	0.65	0.82	0.92	1.00
26	B026*	0.47	0.82	0.93	0.87	0.97	1.00
27	B027	0.61	0.90	0.90	0.92	0.94	0.97
28	B028*	0.61	0.82	0.88	0.95	0.97	0.97
29	B029*	0.53	0.70	0.70	0.84	0.86	0.94
30	B030	0.33	0.35	0.45	0.53	0.56	0.92
31	B031	0.56	0.65	0.77	0.87	0.97	1.00
32	B032*	0.47	0.55	0.75	0.84	0.86	0.94
33	B033	0.44	0.47	0.63	0.84	0.89	0.97
34	B034	0.75	0.90	0.90	0.97	1.00	0.97
35	B035	0.39	0.47	0.55	0.55	0.83	0.92
SCORE RANGE		1-18	19-21	22-24	25-26	27-29	30-34
MEAN ABILITY		-0.42	0.31	0.77	1.15	1.63	2.75
MEAN Z-TEST		0.0	0.0	0.1	0.1	0.2	0.1
SD(Z-TEST)		1.2	0.9	0.7	0.9	1.0	1.0
GROUP COUNT		36	40	40	38	36	36

Note. Asterisks designate the 15 linking items.

Table 5
FIT ORDER: Form A
(n=225-3-8=214)

SEQ NUM	ITEM NAME	ITEM DIFF	ERR IMPAC	FIT BETWN	t-TESTS TOTAL	WTD MNSQ	MNSQ SD	DISC INDX	POINT BISER
27	A026	0.43	0.00	0.64	-1.97	0.88	0.06	1.34	0.51
13	A013	0.43	0.00	0.93	-1.72	0.89	0.06	1.32	0.49
12	A012*	0.41	0.00	-0.11	-1.41	0.91	0.07	1.31	0.46
20	A020*	0.60	0.00	-0.34	-1.09	0.94	0.06	1.22	0.45
29	A029*	-0.09	0.00	0.36	-0.98	0.92	0.09	1.25	0.45
18	A018	-1.29	0.00	1.72	-0.84	0.85	0.18	1.64	0.47
2	A002	0.36	0.00	1.06	-0.79	0.95	0.07	1.17	0.42
19	A019*	-0.61	0.00	0.43	-0.77	0.91	0.12	1.37	0.43
4	A004	-0.18	0.00	0.09	-0.77	0.93	0.09	1.24	0.42
25	A025	-0.50	0.00	1.65	-0.71	0.92	0.11	1.14	0.40
1	A001	0.60	0.00	-0.28	-0.65	0.96	0.06	1.17	0.40
11	A011	0.11	0.00	-0.32	-0.53	0.96	0.08	1.21	0.40
16	A016*	-0.40	0.00	0.81	-0.45	0.95	0.10	1.09	0.37
23	A023	-1.08	0.00	-0.45	-0.42	0.93	0.16	1.19	0.36
3	A003*	-1.48	0.00	-0.17	-0.30	0.93	0.20	1.32	0.34
10	A010*	0.55	0.00	0.44	-0.18	0.99	0.06	1.07	0.37
8	A008*	0.00	0.00	-0.39	-0.15	0.99	0.08	1.14	0.36
21	A021*	-0.94	0.00	0.03	-0.11	0.98	0.14	1.02	0.31
31	A031	-0.27	0.00	-1.10	-0.08	0.99	0.10	0.97	0.35
28	A028	-0.18	0.00	0.06	-0.08	0.99	0.09	0.91	0.34
27	A027	-0.94	0.00	-1.02	-0.03	0.99	0.14	1.01	0.29
32	A032	-0.33	0.00	0.33	0.07	1.00	0.10	0.92	0.32
34	A034	-0.81	0.00	-0.42	0.08	1.00	0.13	0.88	0.28
22	A022*	-1.96	0.00	0.09	0.09	1.00	0.26	0.84	0.16
6	A006*	0.02	0.00	-1.38	0.11	1.01	0.08	0.96	0.34
7	A007*	1.84	0.00	-1.23	0.18	1.01	0.06	1.00	0.35
35	A035	-0.98	0.03	2.26	0.44	1.06	0.15	0.58	0.18
24	A024*	-0.03	0.02	0.13	0.58	1.05	0.08	0.78	0.29
33	A033	0.02	0.02	0.17	0.64	1.05	0.08	0.69	0.29
17	A017	0.43	0.03	0.04	0.91	1.06	0.06	0.71	0.30
14	A014*	-0.40	0.05	1.86	0.93	1.10	0.10	0.40	0.18
9	A009	1.90	0.03	1.51	0.96	1.06	0.06	0.74	0.27
15	A015*	1.84	0.03	-1.84	1.13	1.07	0.06	0.91	0.32
5	A005	1.61	0.04	0.17	1.32	1.07	0.06	0.77	0.27
30	A030	1.28	0.06	2.29	2.41	1.13	0.05	0.51	0.26
	MEAN			0.23	-0.12	0.98	0.10		
	S.D.			1.00	0.89	0.07	0.05		

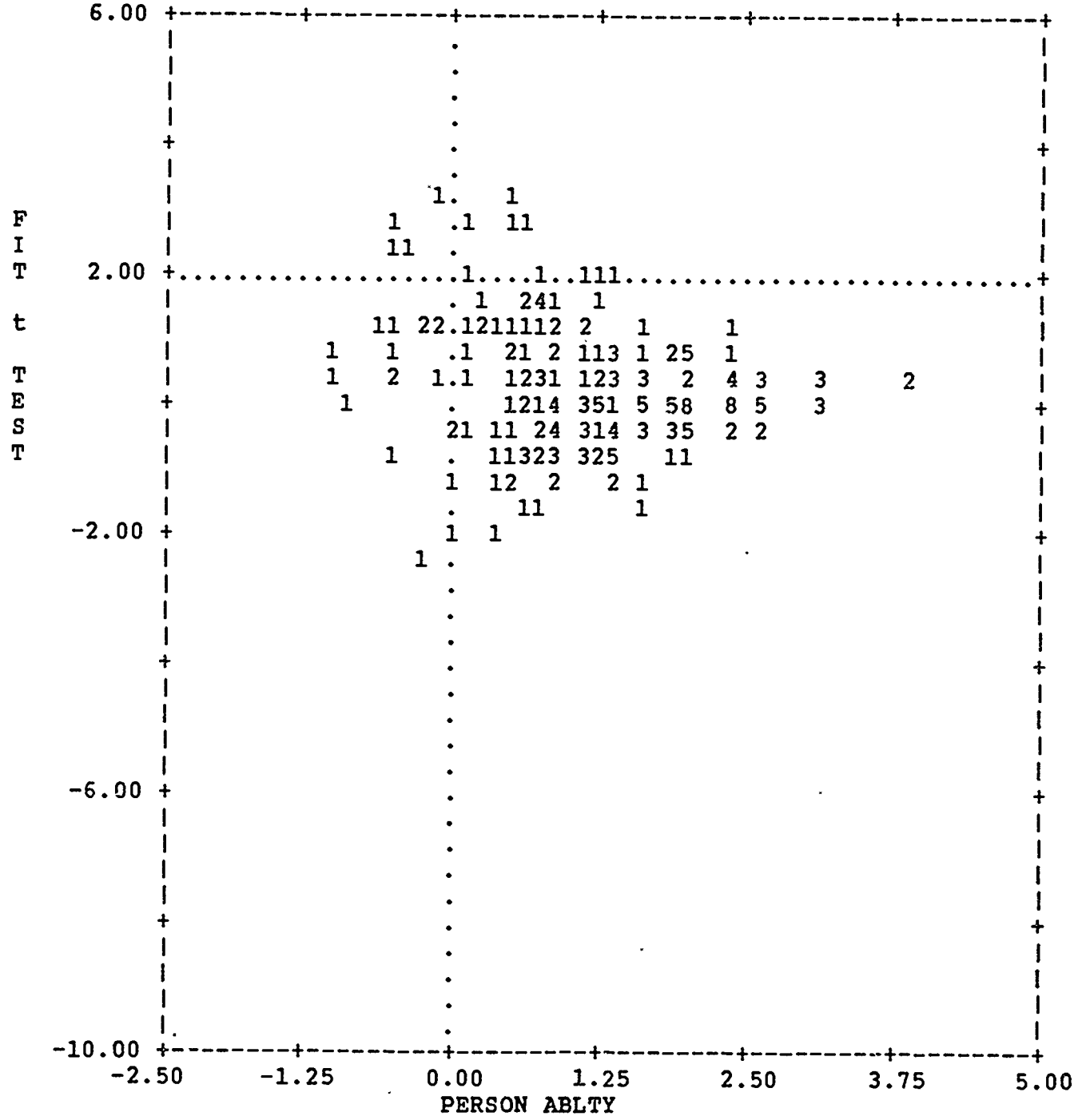
Table 6
FIT ORDER: Form B
(n=232-2-4=226)

SEQ NUM	ITEM NAME	ITEM DIFF	ERR IMPAC	FIT t-TESTS BETWN	TOTAL	WTD MNSQ	MNSQ SD	DISC INDX	POINT BISER
25	B025	0.17	0.00	1.86	-2.70	0.84	0.06	1.54	0.55
22	B022*	-0.14	0.00	1.07	-1.77	0.87	0.07	1.38	0.50
10	B010	0.51	0.00	0.76	-1.74	0.91	0.05	1.24	0.49
20	B020	-0.38	0.00	1.06	-1.16	0.90	0.08	1.36	0.46
33	B033	-0.02	0.00	0.42	-1.15	0.92	0.07	1.18	0.46
24	B024	0.76	0.00	-0.26	-1.04	0.95	0.05	1.16	0.46
26	B026*	-0.95	0.00	1.12	-0.87	0.90	0.12	1.37	0.43
18	B018*	-1.02	0.00	1.08	-0.86	0.89	0.12	1.33	0.41
11	B011*	0.19	0.00	-0.16	-0.65	0.96	0.06	1.12	0.42
3	B003	2.68	0.00	0.92	-0.59	0.93	0.11	1.22	0.40
7	B007	0.97	0.00	0.90	-0.57	0.97	0.05	1.11	0.46
31	B031	-0.61	0.00	0.04	-0.47	0.95	0.10	1.22	0.39
32	B032*	-0.19	0.00	-1.22	-0.37	0.97	0.08	1.03	0.39
27	B027	-1.23	0.00	-0.58	-0.22	0.96	0.14	1.07	0.31
19	B019	-2.29	0.00	0.24	-0.19	0.93	0.26	1.47	0.32
28	B028*	-1.14	0.00	-1.03	-0.19	0.97	0.13	1.16	0.33
5	B005*	-0.32	0.00	0.24	-0.15	0.99	0.08	0.91	0.36
34	B034	-1.68	0.00	-0.48	-0.14	0.96	0.19	1.08	0.29
14	B014*	0.17	0.00	-1.31	-0.09	0.99	0.06	0.89	0.39
1	B001*	-1.74	0.00	0.36	-0.06	0.98	0.19	1.28	0.30
16	B016	0.37	0.00	-0.61	0.04	1.00	0.06	1.04	0.39
21	B021*	-1.27	0.01	-1.43	0.19	1.02	0.15	0.83	0.24
9	B009*	-0.71	0.01	0.29	0.21	1.02	0.10	0.84	0.29
13	B013	2.15	0.01	1.07	0.28	1.02	0.08	1.00	0.33
8	B008	0.10	0.01	1.12	0.39	1.02	0.06	0.90	0.35
15	B015*	-1.06	0.03	0.15	0.44	1.05	0.13	0.70	0.21
30	B030	0.91	0.01	0.68	0.46	1.02	0.05	0.87	0.39
12	B012	0.08	0.02	-0.09	0.65	1.04	0.06	0.93	0.33
29	B029*	-0.35	0.03	-1.37	0.65	1.05	0.08	0.88	0.29
35	B035	0.44	0.02	0.17	0.70	1.04	0.06	0.92	0.35
6	B006*	1.71	0.03	-0.94	0.85	1.06	0.07	0.85	0.37
17	B017*	1.62	0.03	-0.92	1.05	1.07	0.06	0.84	0.35
2	B002	1.69	0.06	0.57	1.75	1.12	0.07	0.69	0.31
23	B023	0.05	0.06	0.98	1.79	1.12	0.07	0.59	0.24
4	B004	0.53	0.10	2.39	3.52	1.20	0.05	0.33	0.20
	MEAN			0.20	-0.06	0.99	0.09		
	S.D.			0.94	1.12	0.08	0.05		

Table 7
Item Fit and Calibrations for 15 Linking Items

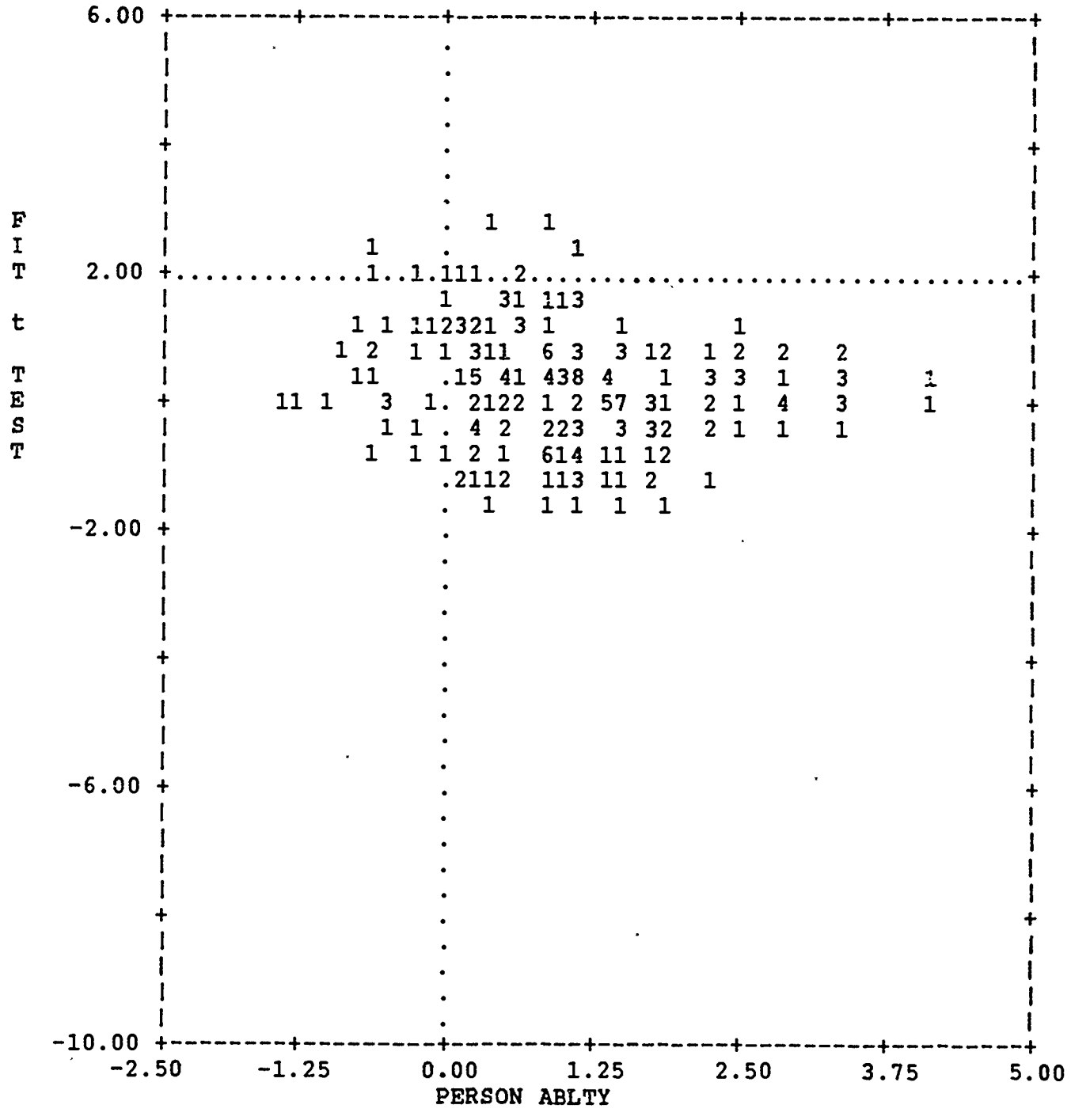
ITEM NAME	ITEM DIFF	ERR IMPAC	FIT t-TESTS BETWN	TOTAL	WTD MNSQ	MNSQ SD	DISC INDX	POINT BISER
Linking Item #1								
A003*	-1.48	0.00	-0.17	-0.30	0.93	0.20	1.32	0.34
B001*	-1.74	0.00	0.36	-0.06	0.98	0.19	1.28	0.30
Linking Item #2								
A006*	0.02	0.00	-1.38	0.11	1.01	0.08	0.96	0.34
B005*	-0.32	0.00	0.24	-0.15	0.99	0.08	0.91	0.36
Linking Item #3								
A007*	1.84	0.00	-1.23	0.18	1.01	0.06	1.00	0.35
B006*	1.71	0.03	-0.94	0.85	1.06	0.07	0.85	0.37
Linking Item #4								
A008*	0.00	0.00	-0.39	-0.15	0.99	0.08	1.14	0.36
B009*	-0.71	0.01	0.29	0.2[illegible]	1.02	0.10	0.84	0.29
Linking Item #5								
A010*	0.55	0.00	0.44	-0.18	0.99	0.06	1.07	0.37
B011*	0.19	0.00	-0.16	-0.65	0.96	0.06	1.12	0.42
Linking Item #6								
A012*	0.41	0.00	-0.11	-1.41	0.91	0.07	1.31	0.46
B014*	0.17	0.00	-1.31	-0.09	0.99	0.06	0.89	0.39
Linking Item #7								
A014*	-0.40	0.05	1.86	0.93	1.10	0.10	0.40	0.18
B015*	-1.06	0.03	0.15	0.44	1.05	0.13	0.70	0.21
Linking Item #8								
A015*	1.84	0.03	-1.84	1.13	1.07	0.06	0.91	0.32
B017*	1.62	0.03	-0.92	1.05	1.07	0.06	0.84	0.35
Linking Item #9								
A016*	-0.40	0.00	0.81	-0.45	0.95	0.10	1.09	0.37
B018*	-1.02	0.00	1.08	-0.86	0.89	0.12	1.33	0.41
Linking Item #10								
A019*	-0.61	0.00	0.43	-0.77	0.91	0.12	1.37	0.43
B021*	-1.27	0.01	-1.43	0.19	1.02	0.15	0.83	0.24
Linking Item #11								
A020*	0.60	0.00	-0.34	-1.09	0.94	0.06	1.22	0.45
B022*	-0.14	0.00	1.07	-1.77	0.87	0.07	1.38	0.50
Linking Item #12								
A021*	-0.94	0.00	0.03	-0.11	0.98	0.14	1.02	0.31
B026*	-0.95	0.00	1.12	-0.87	0.90	0.12	1.37	0.43
Linking Item #13								
A022*	-1.96	0.00	0.09	0.09	1.00	0.26	0.84	0.16
B028*	-1.14	0.00	-1.03	-0.19	0.97	0.13	1.16	0.33
Linking Item #14								
A024*	-0.03	0.02	0.13	0.58	1.05	0.08	0.78	0.29
B029*	-0.35	0.03	-1.37	0.65	1.05	0.08	0.88	0.29
Linking Item #15								
A029*	-0.09	0.00	0.36	-0.98	0.92	0.09	1.25	0.45
B032*	-0.19	0.00	-1.22	-0.37	0.97	0.08	1.03	0.39

Figure 1
ABILITY BY FIT t-TEST FOR EACH PERSON (MNt = .01; SDt = .96): Form A
(n=225-3=222)



Note. Eight "misfitting" persons are plotted above the horizontal fit t equals 2.00 line.

Figure 2
ABILITY BY FIT t-TEST FOR EACH PERSON (MNt = .01; SDt = .88): Form B
(n=232-2=230)



Note. Four "misfitting" persons are plotted above the horizontal fit t equals 2.00 line.

Figure 3. COMPLETE SCORE EQUIVALENCE TABLE: Form A

RAW SCORE	COUNT	LOG ABILITY	STANDARD ERRORS
34	2	3.85	1.03
33	6	3.12	0.75
32	10	2.66	0.63
31	16	2.32	0.56
30	21	2.04	0.51
29	11	1.79	0.48
28	15	1.58	0.46
27	19	1.39	0.44
26	13	1.21	0.42
25	14	1.04	0.41
24	19	0.89	0.40
23	15	0.74	0.39
22	12	0.59	0.38
21	9	0.45	0.38
20	5	0.32	0.37
19	3	0.18	0.37
18	5	0.05	0.37
17	4	-0.08	0.37
16	3	-0.22	0.37
15	3	-0.35	0.37
14	0	-0.48	0.37
13	5	-0.62	0.38
12	1	-0.76	0.38
11	1	-0.91	0.39
10	2	-1.06	0.40
9	0	-1.22	0.41
8	0	-1.39	0.43
7	0	-1.58	0.45
6	0	-1.78	0.47
5	0	-2.02	0.51
4	0	-2.29	0.55
3	0	-2.62	0.62
2	0	-3.07	0.74
1	0	-3.79	1.03

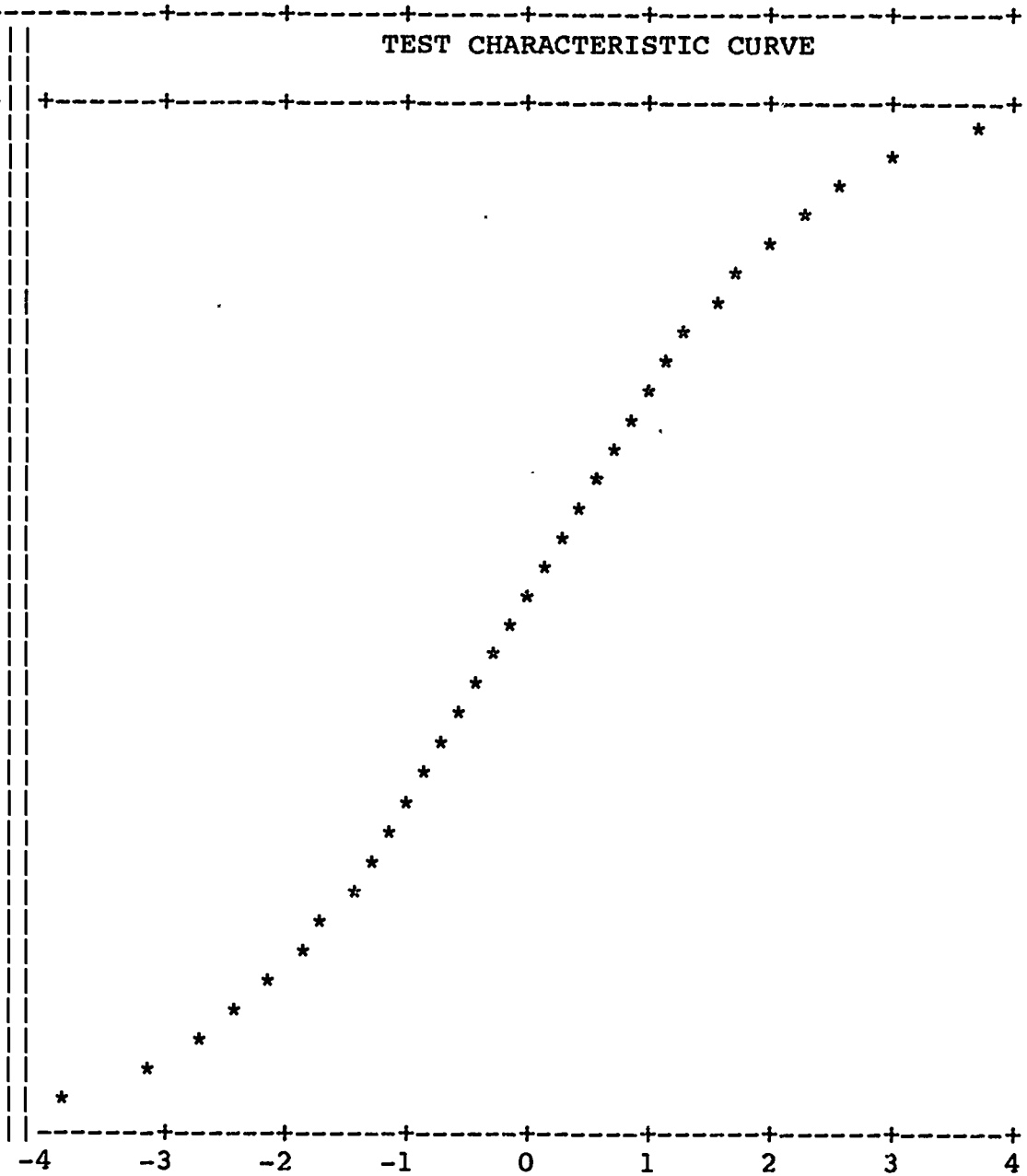


Figure 4. COMPLETE SCORE EQUIVALENCE TABLE: Form B

RAW SCORE	COUNT	LOG ABILITY	STANDARD ERRORS
34	2	4.04	1.04
33	9	3.28	0.76
32	8	2.81	0.65
31	8	2.45	0.58
30	9	2.15	0.53
29	9	1.90	0.49
28	10	1.67	0.47
27	17	1.47	0.45
26	11	1.28	0.43
25	27	1.10	0.42
24	8	0.94	0.41
23	23	0.78	0.40
22	9	0.62	0.39
21	15	0.47	0.39
20	5	0.33	0.38
19	20	0.19	0.38
18	7	0.05	0.38
17	6	-0.09	0.38
16	2	-0.23	0.38
15	5	-0.37	0.38
14	5	-0.52	0.39
13	5	-0.66	0.39
12	2	-0.81	0.40
11	1	-0.97	0.40
10	1	-1.13	0.41
9	1	-1.30	0.42
8	1	-1.48	0.44
7	0	-1.67	0.46
6	0	-1.89	0.48
5	0	-2.13	0.52
4	0	-2.41	0.56
3	0	-2.75	0.63
2	0	-3.21	0.75
1	0	-3.95	1.03

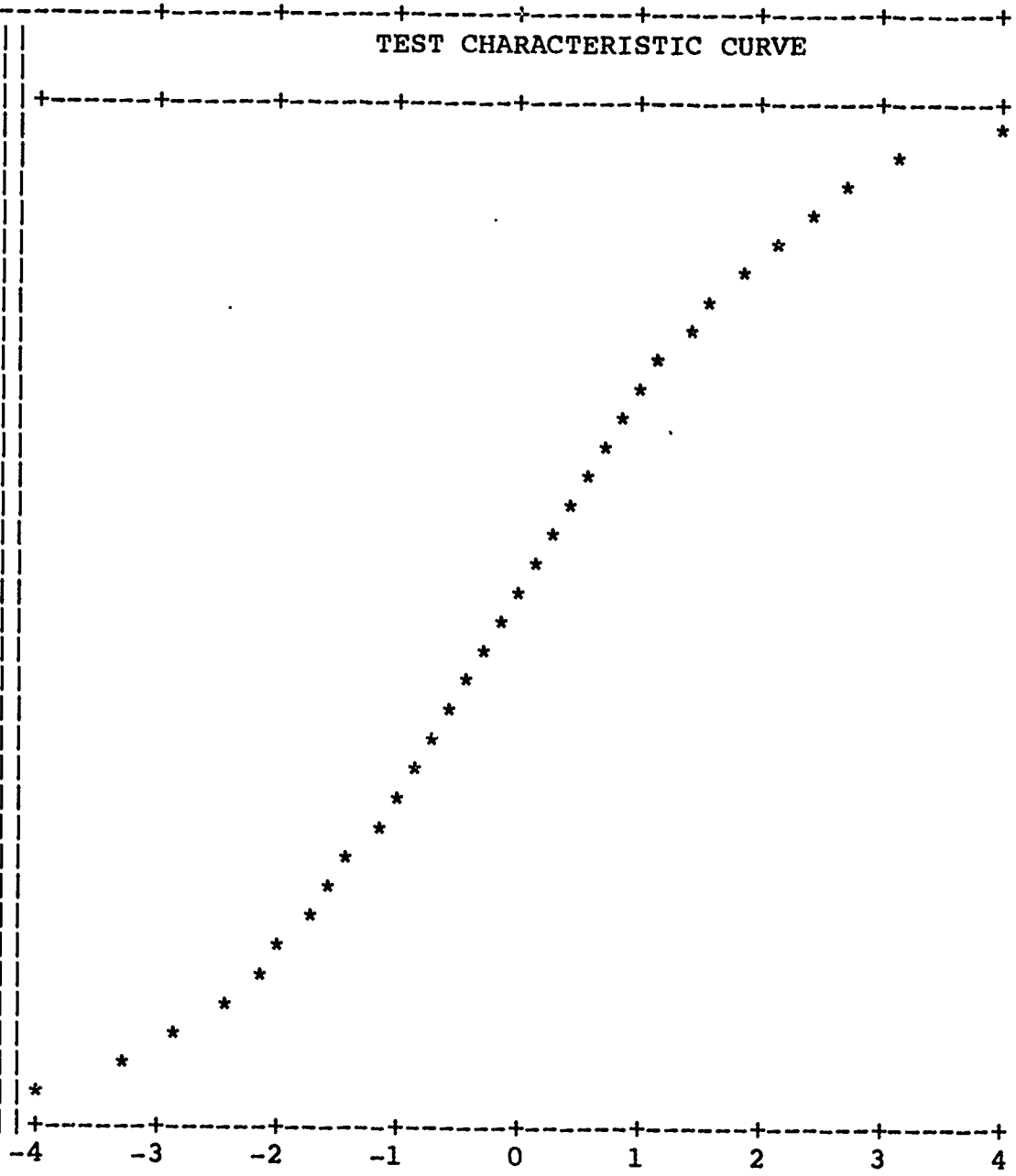


Figure 5
MAP OF VARIABLE: Form A
(n=225-3-8=214)

	RAW SCORE	MEASURE MIDPOINT(S.E.)	ITEM COUNTS	TYPICAL ITEMS (BY NAME)
	34	3.90(1.03)		
+3SD		3.70(1.03)		
		3.50(1.03)		
		3.30(1.03)		
	33	3.10(0.75)		
+2SD		2.90(0.75)		
	32	2.70(0.63)		
		2.50(0.63)		
	31	2.30(0.56)		
+1SD	30	2.10(0.51)		
		1.90(0.51)	3	A07 A09 A15
	29	1.70(0.48)	1	A05
	28	1.50(0.46)		
MEAN	26	1.30(0.42)	1	A30
	25	1.10(0.41)		
	24	0.90(0.40)		
	23	0.70(0.39)		
-1SD	21	0.50(0.38)	7	A01 A10 A12 A13 A17 A20 A26
	20	0.30(0.37)	1	A02
	18	0.10(0.37)	3	A06 A11 A33
	17	-0.10(0.37)	5	A04 A08 A24 A28 A29
-2SD	15	-0.30(0.37)	4	A14 A16 A31 A32
	14	-0.50(0.37)	1	A25
	12	-0.70(0.38)	1	A19
	11	-0.90(0.39)	4	A21 A27 A34 A35
-3SD	10	-1.10(0.40)	1	A23
	8	-1.30(0.43)	1	A18
	7	-1.50(0.45)	1	A03
	6	-1.70(0.47)		
-4SD		-1.90(0.47)	1	A22
	5	-2.10(0.51)		

Figure 6
MAP OF VARIABLE: Form B
(n=232-2-4=226)

RAW SCORE	MEASURE MIDPOINT(S.E.)	ITEM COUNTS	TYPICAL ITEMS (BY NAME)
34	4.10(1.04)		
	3.90(1.04)		
+3SD	3.70(1.04)		
	3.50(1.04)		
33	3.30(0.76)		
	3.10(0.76)		
+2SD 32	2.90(0.65)		
	2.70(0.65)	1	B03
31	2.50(0.58)		
	2.30(0.58)		
30	2.10(0.53)	1	B13
+1SD 29	1.90(0.49)		
28	1.70(0.47)	3	B02 B06 B17
27	1.50(0.45)		
26	1.30(0.43)		
MEAN 25	1.10(0.42)		
24	0.90(0.41)	2	B07 B30
22	0.70(0.39)	1	B24
21	0.50(0.39)	3	B04 B10 B35
20	0.30(0.38)	1	B16
-1SD 18	0.10(0.38)	6	B08 B11 B12 B14 B23 B25
17	-0.10(0.38)	3	B22 B32 B33
15	-0.30(0.38)	3	B05 B20 B29
14	-0.50(0.39)		
13	-0.70(0.39)	2	B09 B31
-2SD 11	-0.90(0.40)	1	B26
10	-1.10(0.41)	3	B15 B18 B28
9	-1.30(0.42)	2	B21 B27
8	-1.50(0.44)		
-3SD 7	-1.70(0.46)	2	B01 B34
6	-1.90(0.48)		
5	-2.10(0.52)		
	-2.30(0.52)	1	B19

Figure 7. TOTAL FIT t-TEST (Y) VERSUS DIFFICULTY (X) (CORR = 0.30): Form A

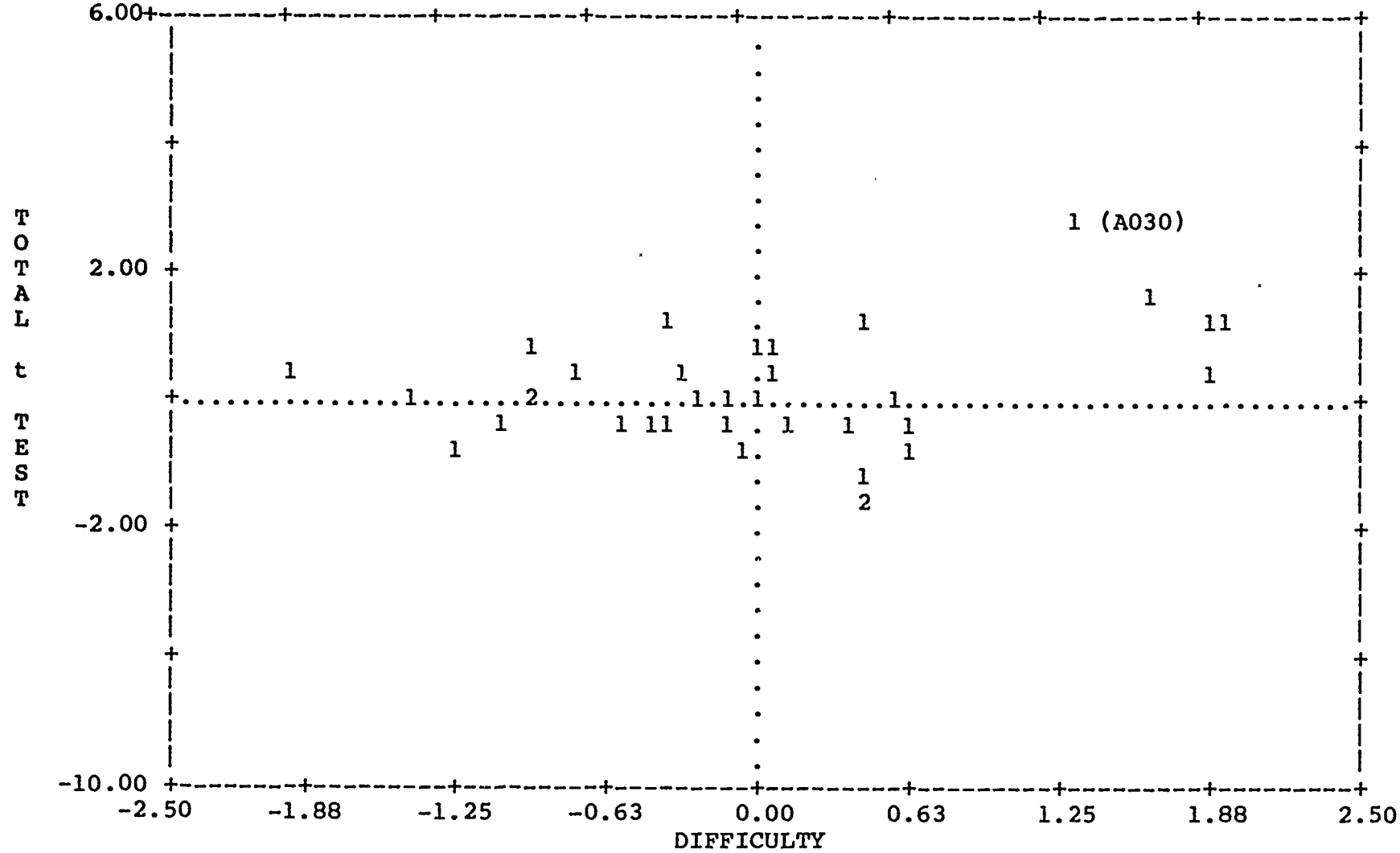


Figure 8. TOTAL FIT t-TEST (Y) VERSUS DIFFICULTY (X) (CORR = 0.19): Form B

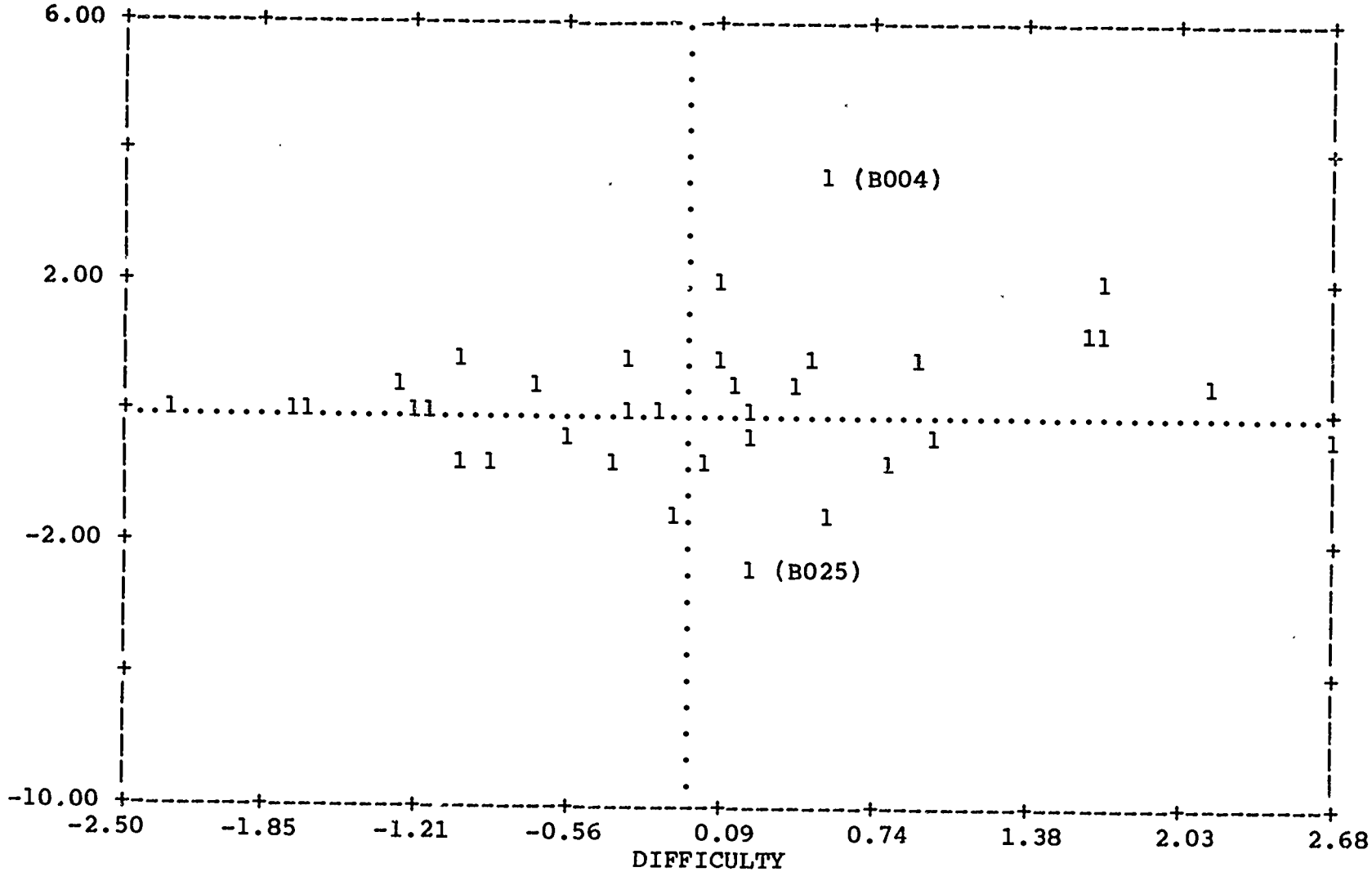


Figure 9. BETWEEN FIT t-TEST (Y) VS DIFFICULTY (X) (CORR = -0.11): Form A

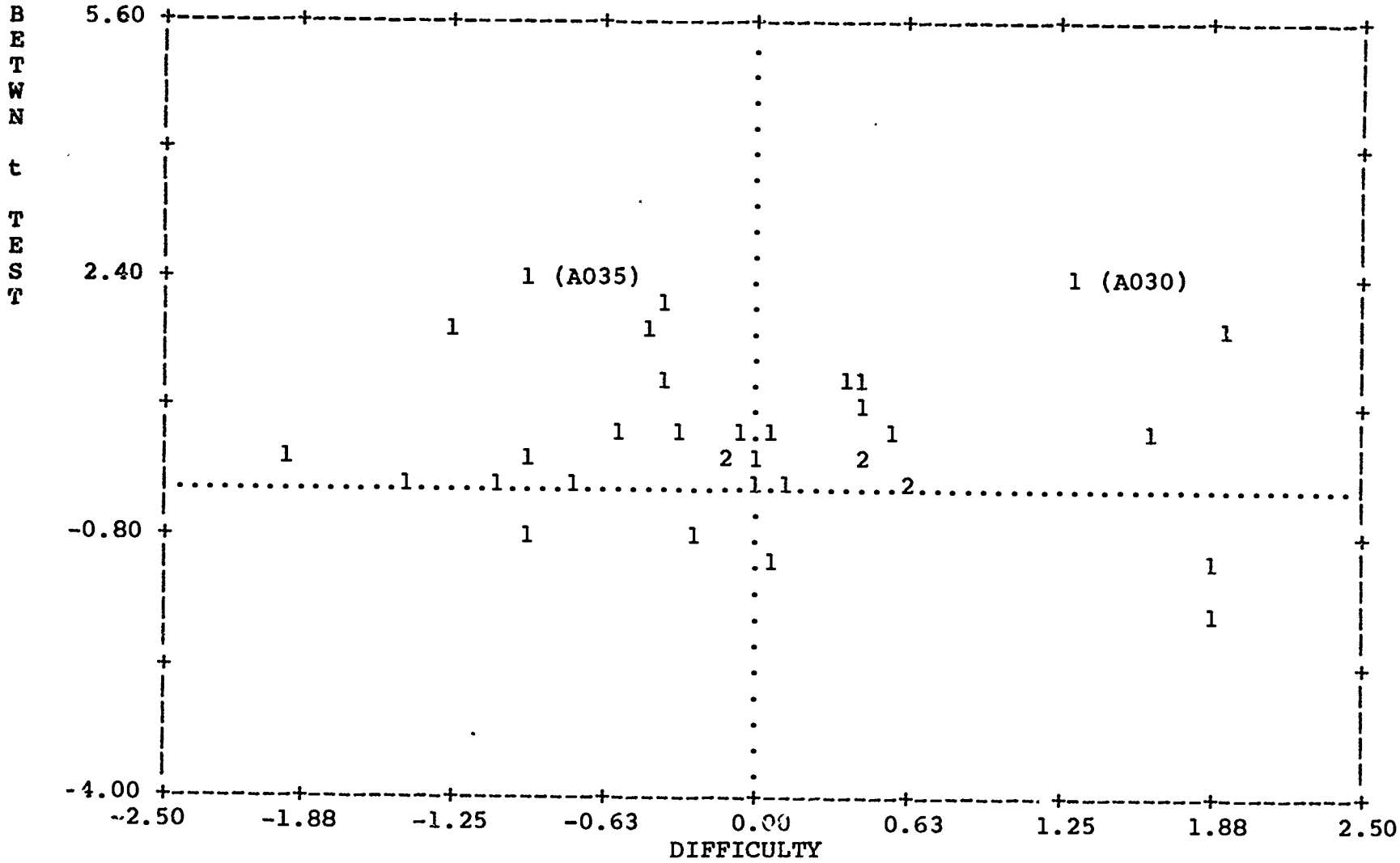


Figure 10. BETWEEN FIT t-TEST (Y) VS DIFFICULTY (X) (CORR = 0.18): Form B

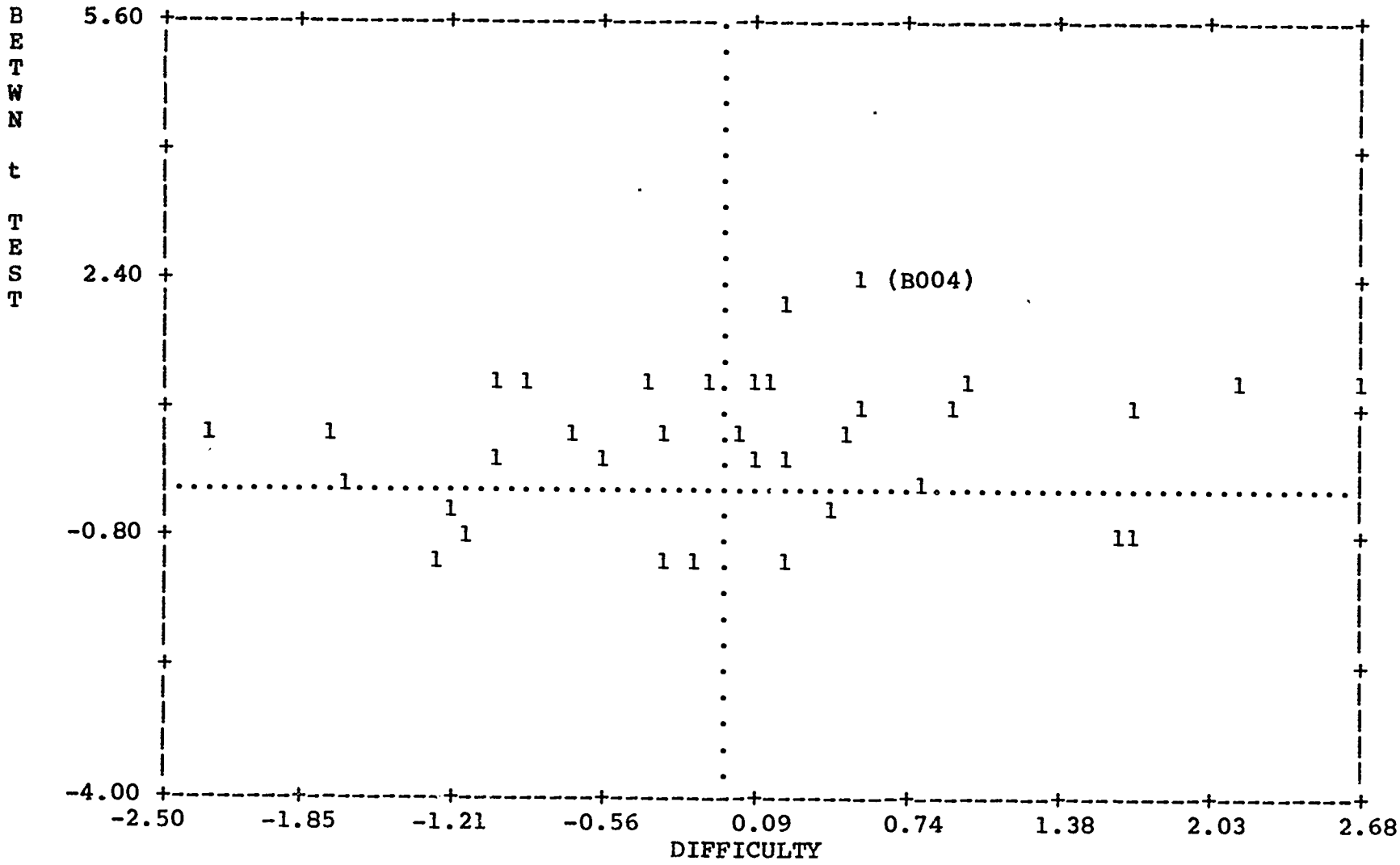


Figure 11
TOTAL FIT t-TEST (Y) VERSUS DISCRIMINATION (X) (CORR = -0.84): Form A
(n=225-3-8=214)

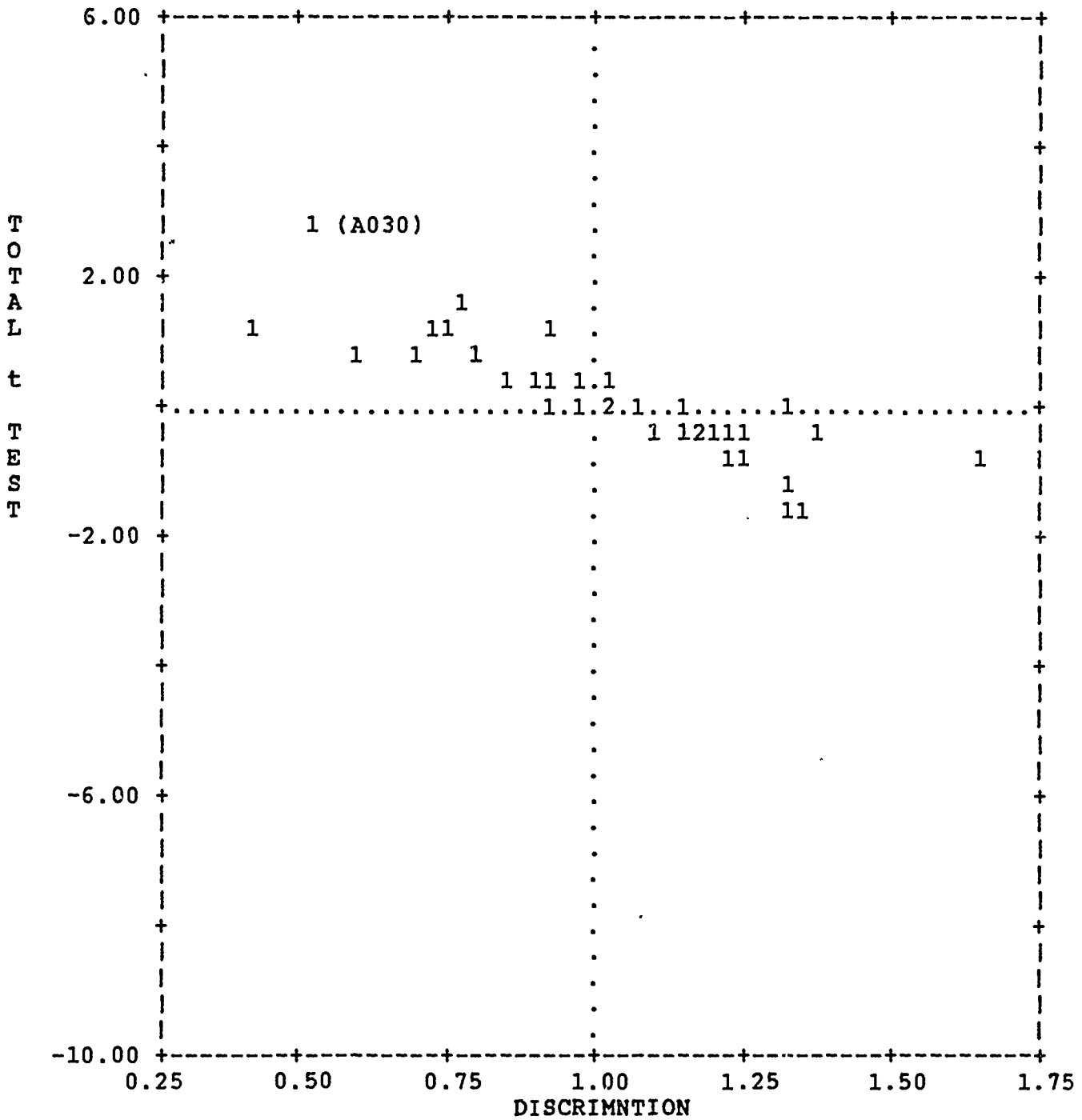


Figure 12
TOTAL FIT t-TEST (Y) VERSUS DISCRIMINATION (X) (CORR = -0.88): Form B
(n=232-2-4=226)

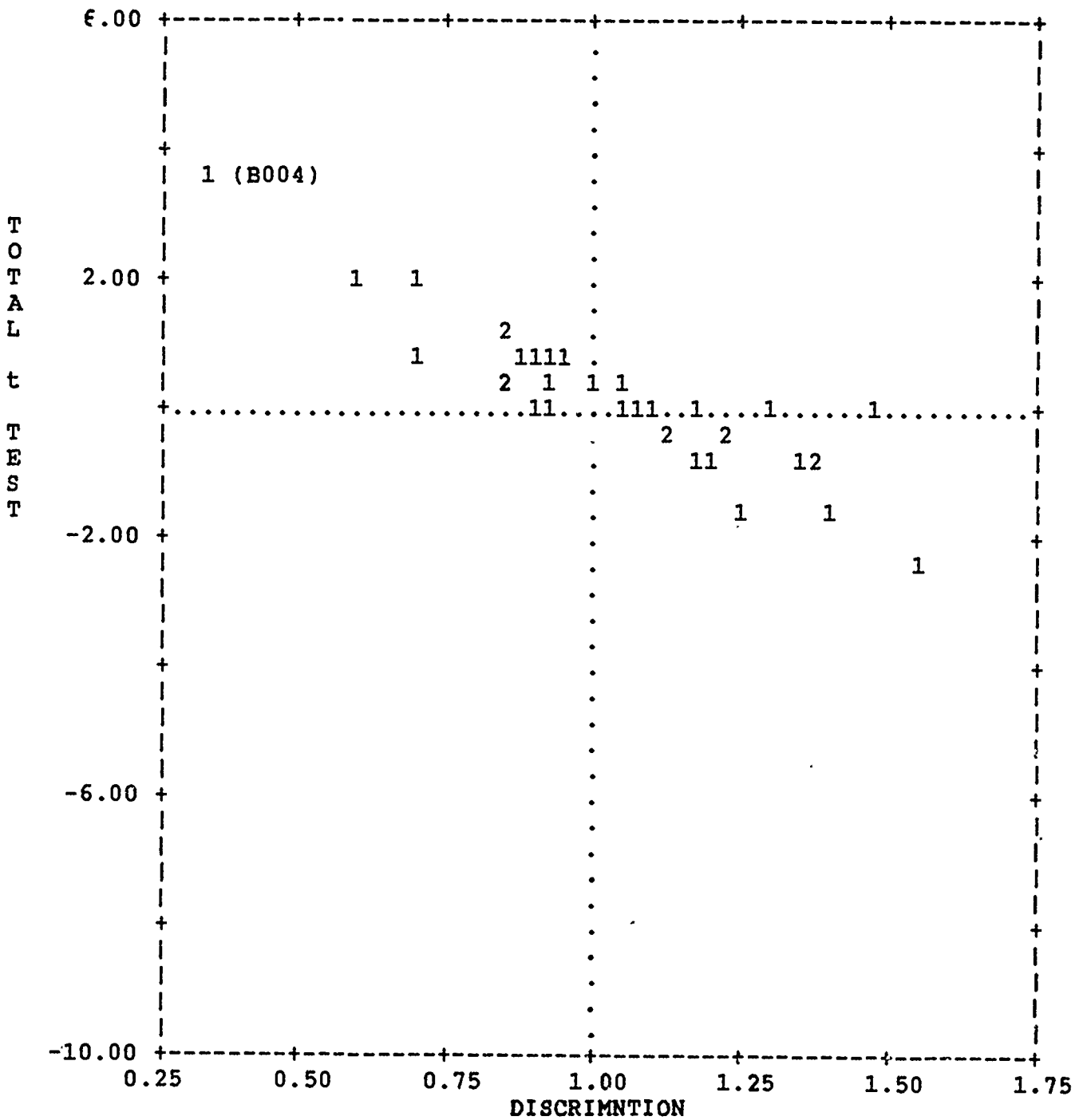


Figure 13
TOTAL FIT t-TEST (Y) VERSUS BETWEEN FIT t-TEST (X): Form A
(n=225-3-8=214)

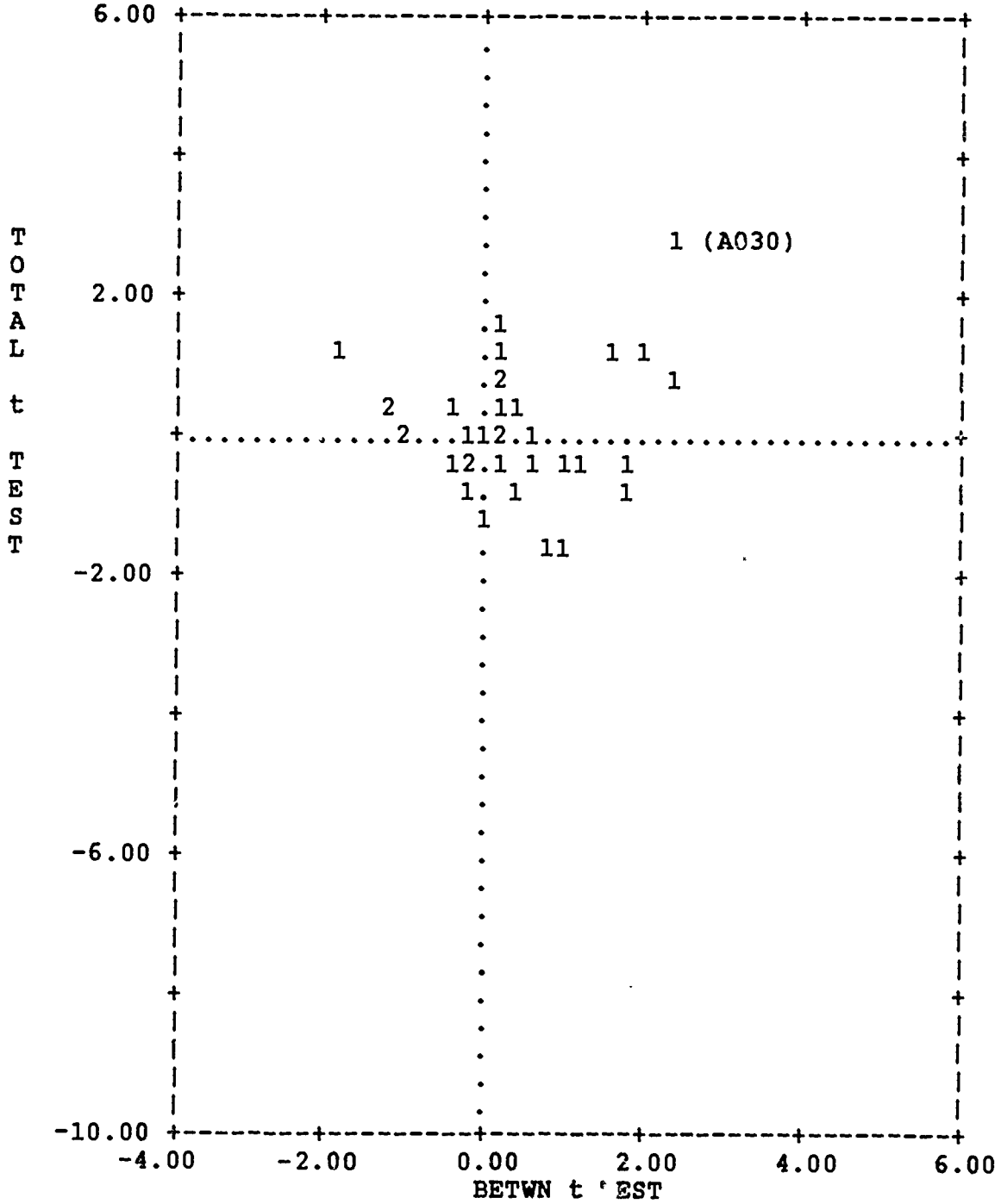


Figure 14
TOTAL FIT t-TEST (Y) VERSUS BETWEEN FIT t-TEST (X): Form B
(n=232-2-4=226)

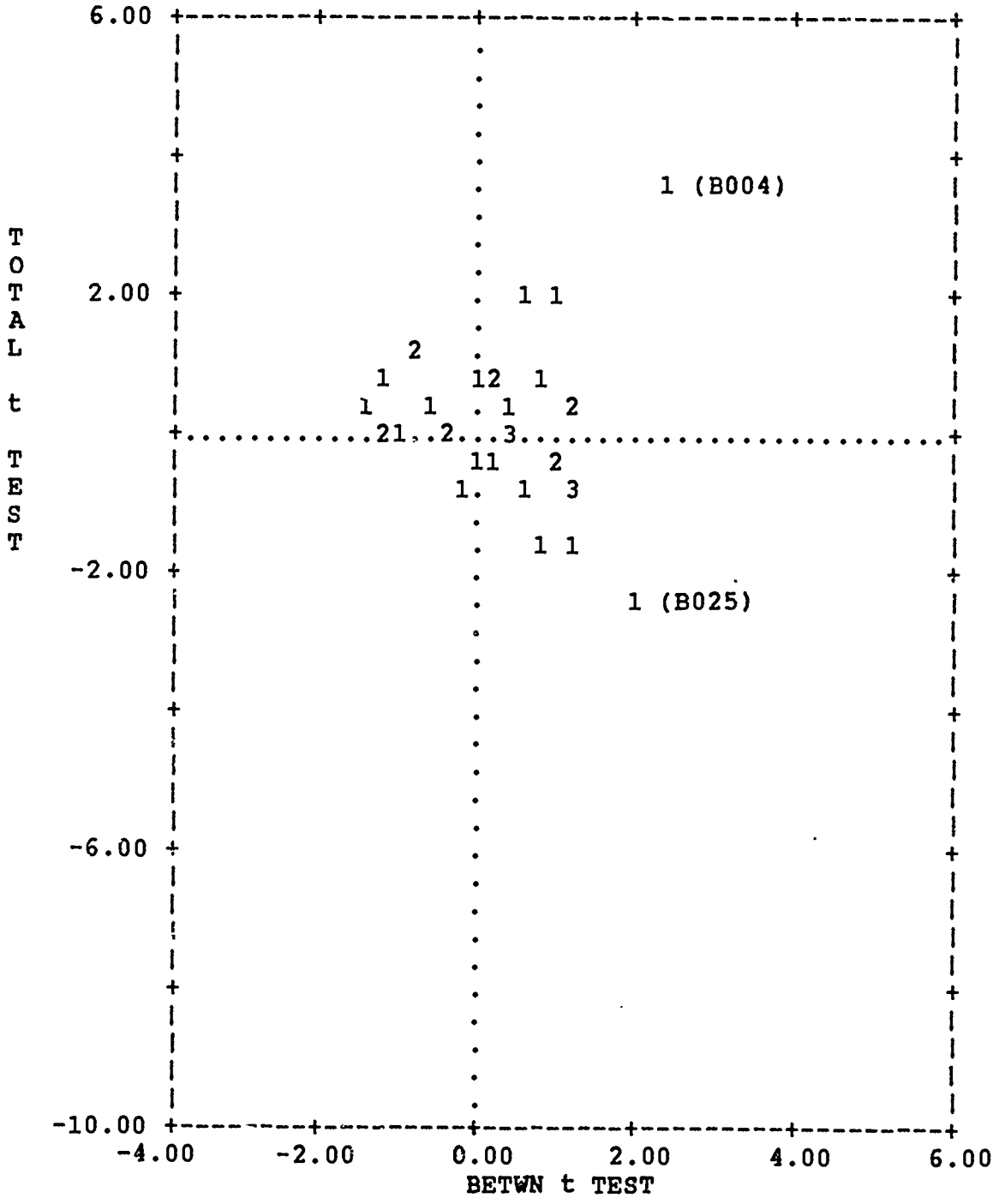
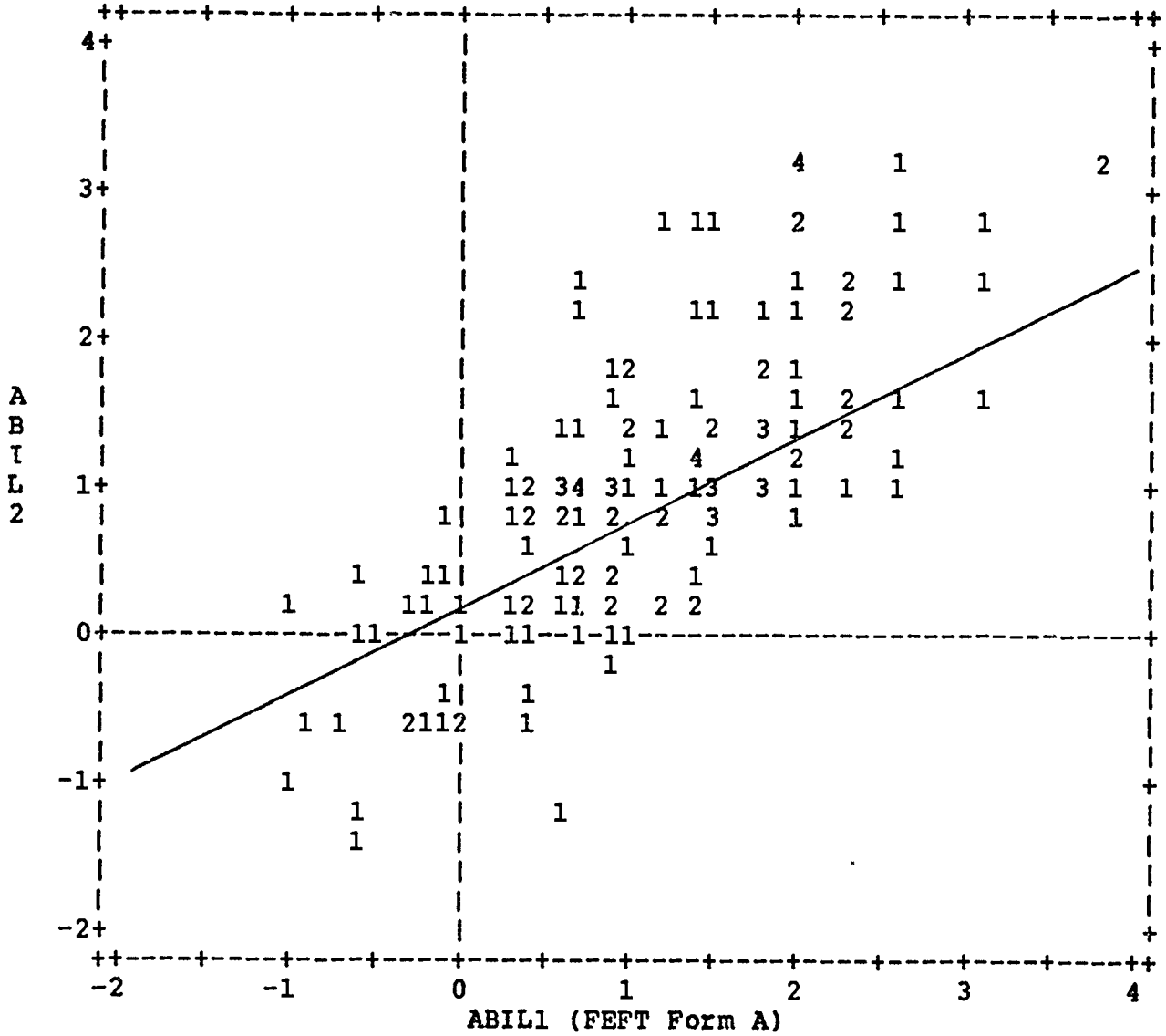


Figure 15
Scattergram of Latent Trait Ability Estimates
for Subjects who Completed Both FEFT Forms
(n=155)



Note. $\hat{Y}$ (least squares estimate of ABIL2) = .1496 + .8095*ABIL1